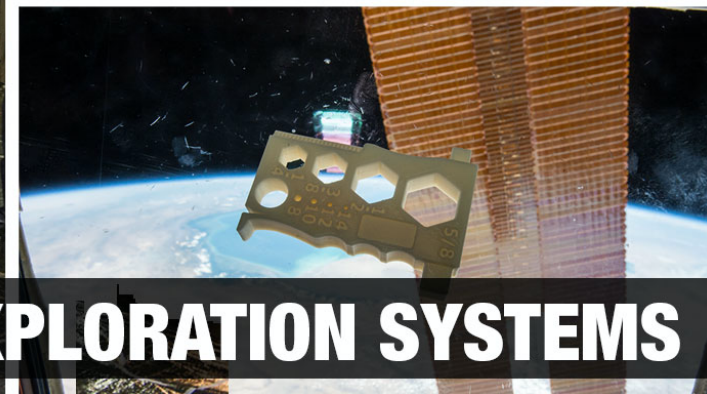
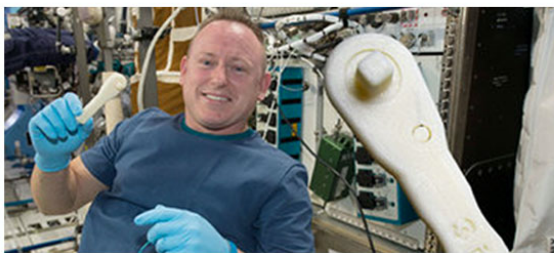


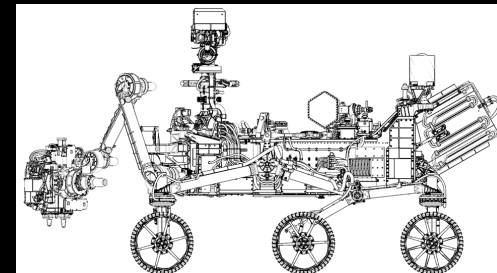
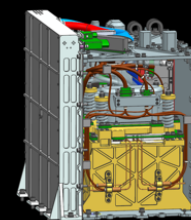
National Aeronautics and Space Administration



## ADVANCED EXPLORATION SYSTEMS

**MOXIE**  
10/11/2018

Michael Hecht | Principal Investigator | MIT  
Jeff Mellstrom | Project Manager | JPL



# MOXIE – Mars Oxygen ISRU Experiment

## Project Overview

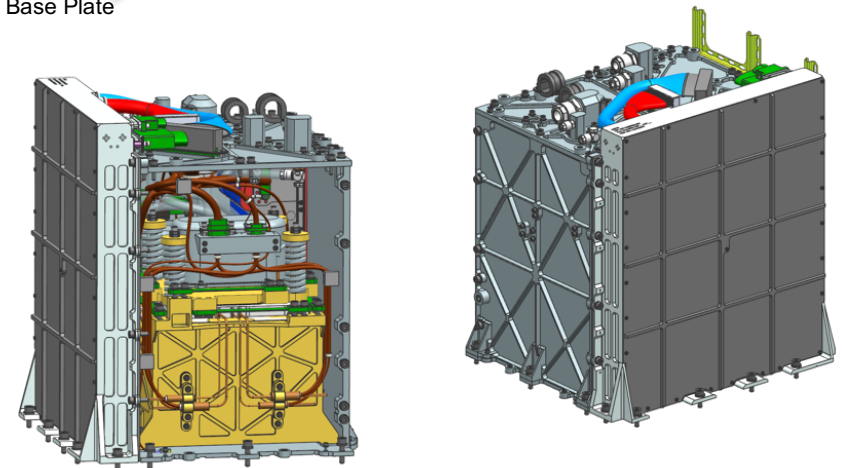
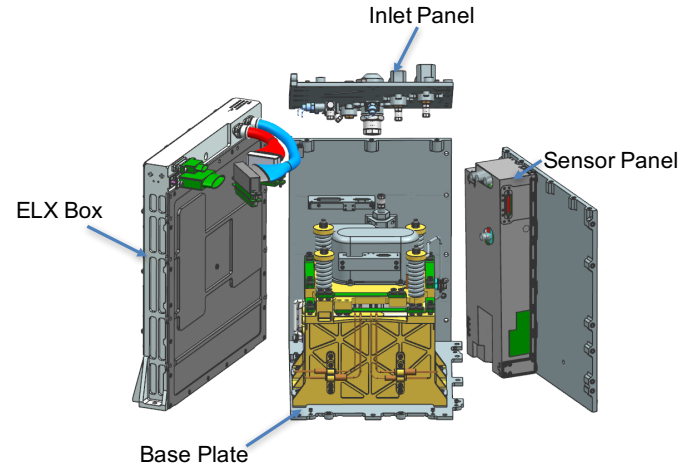


### Why is MOXIE important?

- ISRU (production of O<sub>2</sub> from the atmosphere) for ascent propellant and crew consumables is enabling for robust human exploration missions to Mars.

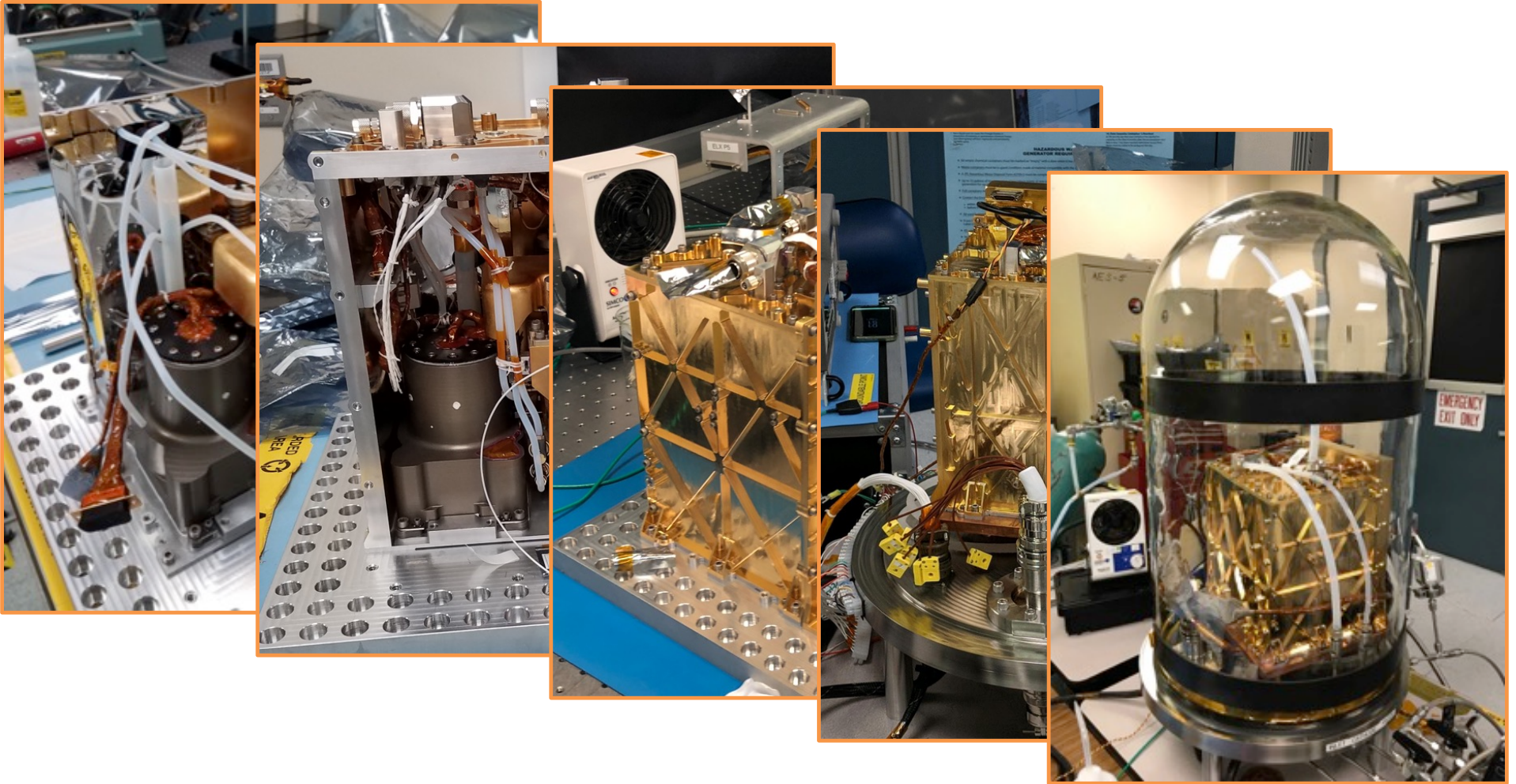
### Objectives

- Meet functional requirements
  - >10 production cycles
  - >6 g/hr of >98% pure O<sub>2</sub>
- Operate MOXIE on Mars as part of M2020 mission
  - Support strategic and tactical planning
  - Analyze, archive, and disseminate data
  - Operate testbeds to support surface ops
- **Inform the design of a full-scale system**

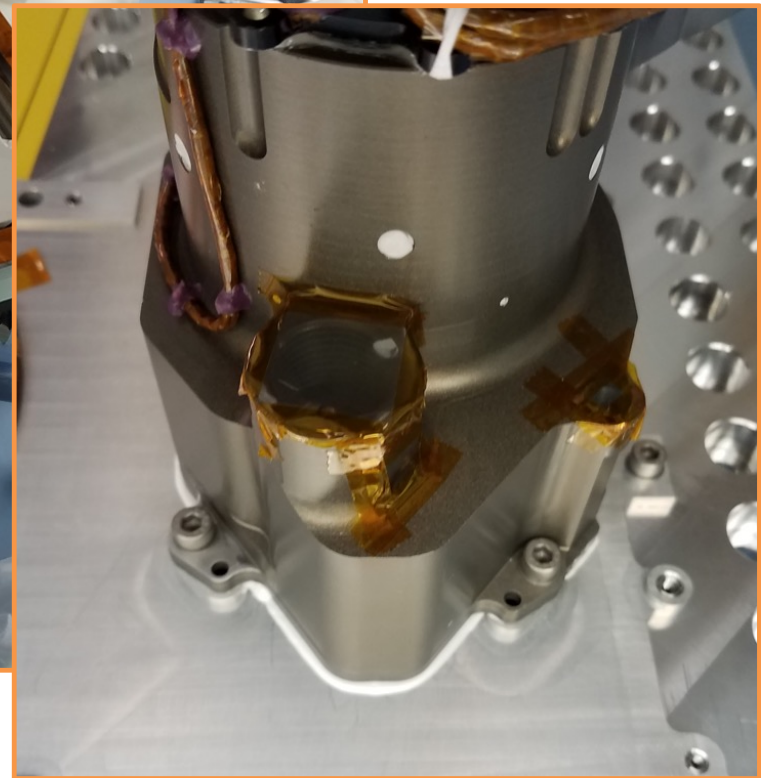
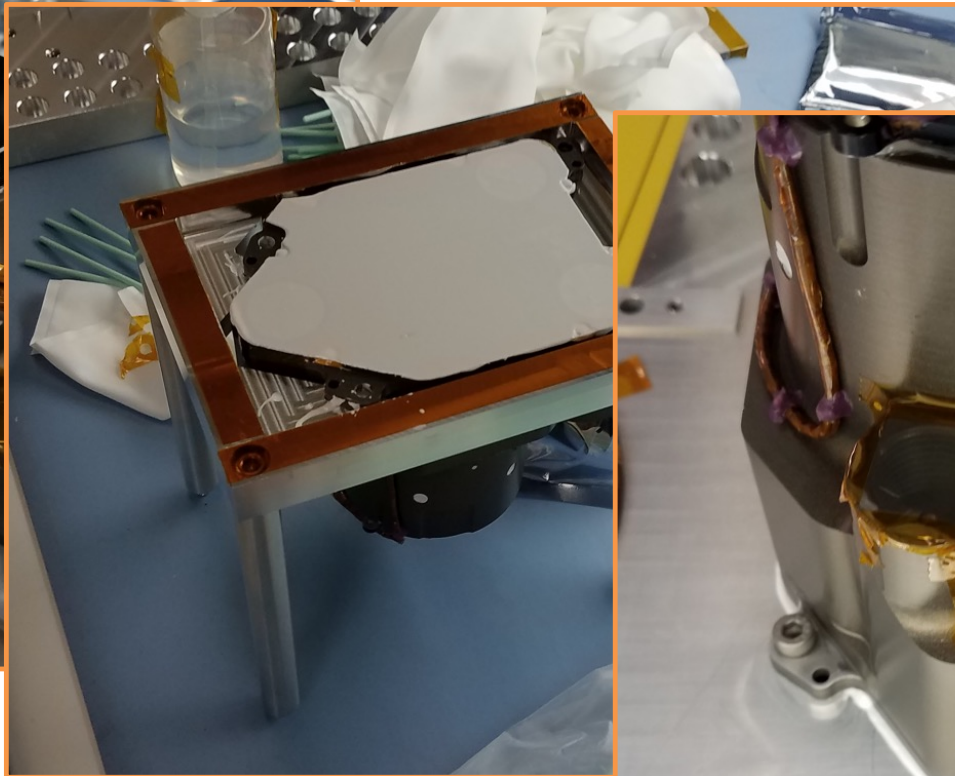
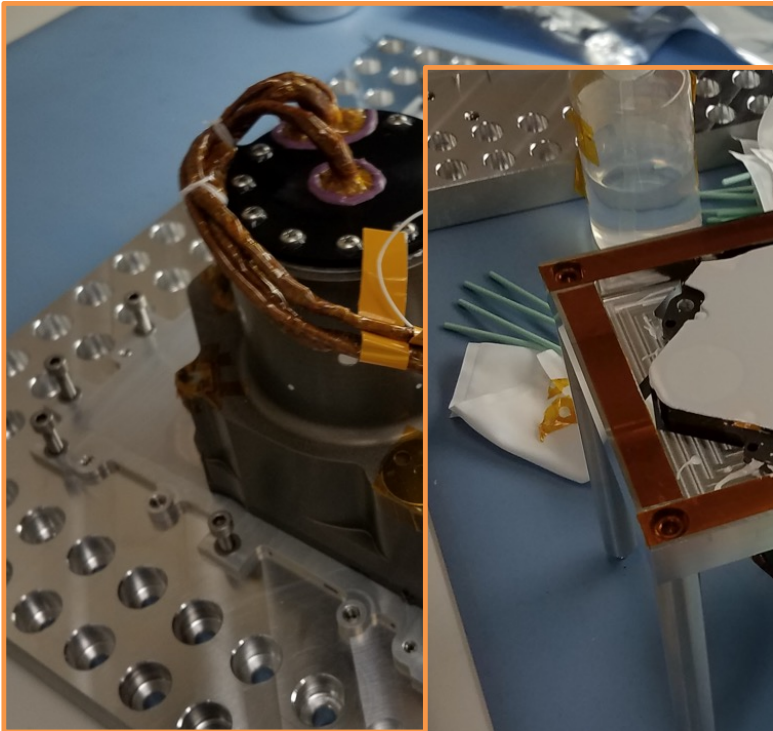




# Major Accomplishments: EM MOXIE Integration



## Major Accomplishment: MOXIE FM Scroll Compressor Integration





## Major Accomplishment: FM Sensors & Sensor Panel Integration

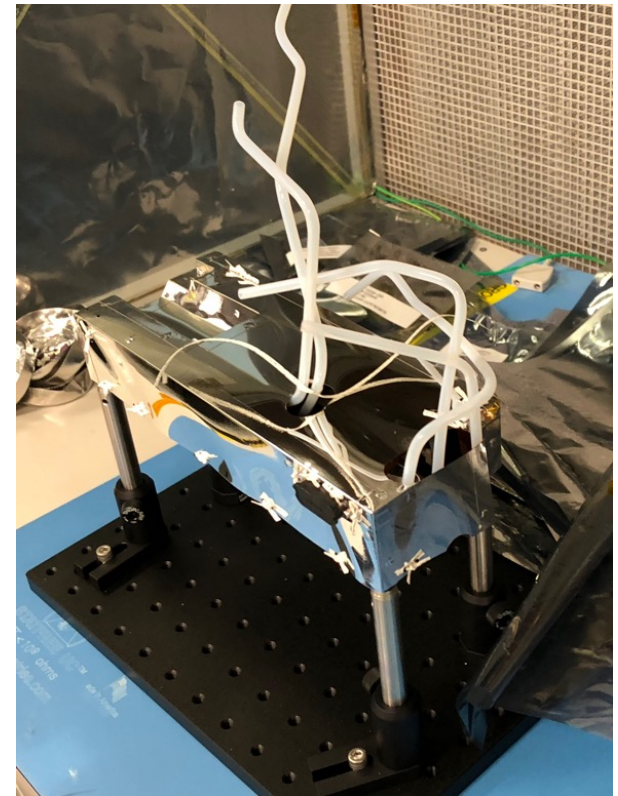


Formed tubing installation



- Cathode Sensors: CO, CO<sub>2</sub>
- Anode Sensors: CO<sub>2</sub>, O<sub>2</sub>
- Viscous Flow Control Devices
- Pressure sensors
- Heat exchangers

Mylar cover installation



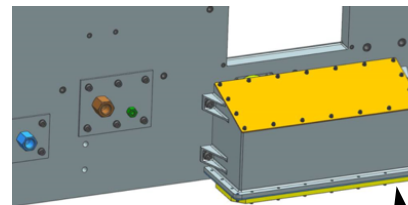
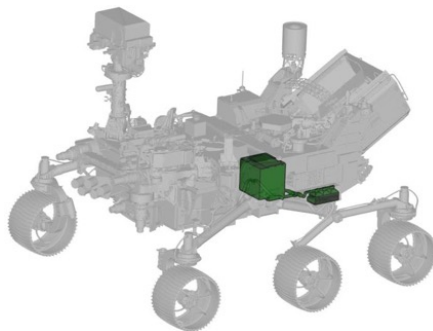
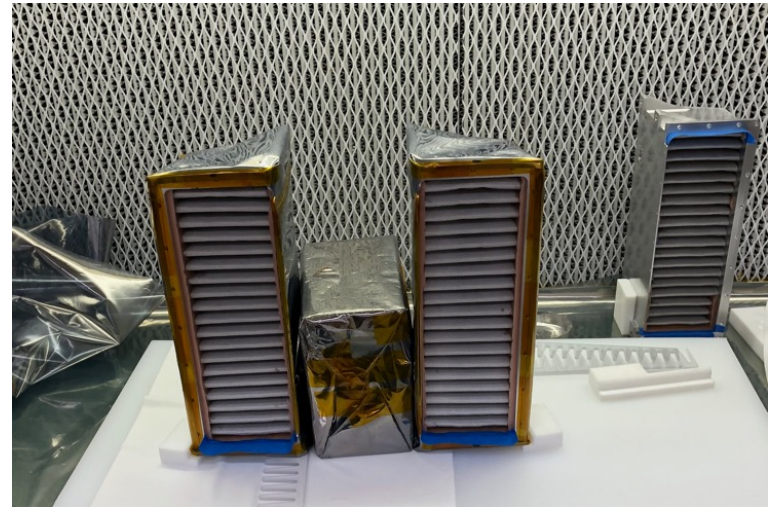
# Major Accomplishment: FM Inlet Filter Integration



Housing



Bonding Flight and Flight Spare filters



Filter Inlet (toward ground)



### Significant Conclusions:

- Filter can tolerate  $\sim 10\times$  more loading than predicted by classical theory (due to Knudsen flow)
  - Allowing  $40 \text{ g/m}^2$  loading,  $\sim 2 \text{ m}^2$  face area would be sufficient for full-scale mission ( $v_{\text{filtration}} < 2 \text{ cm/s}$ )
- Dust loading is  $35\times$  lower than expected from entrained dust density (due to labyrinthine flow through baffle?)
  - If this holds up, filter sizing for full-scale unit will be mostly driven by clean filter resistance, not dust; could reduce to  $< 1 \text{ m}^2$  face area ( $v_{\text{filtration}} < 4 \text{ cm/s}$ )

# MOXIE

## Project Performance



**Performance** (Project Manager's overall assessment)

- = Meeting commitments
- = Have mitigation plans
- = Need external assistance

| Project | Tech | Cost | Sche | Prog | Status  |
|---------|------|------|------|------|---|
| MOXIE   |      |      |      |      | <ul style="list-style-type: none"> <li>• EM is in final test and FM is in final assembly and test.</li> <li>• Deliver FM by Feb, 2019.</li> </ul> |

### **Milestone Status**

| FY18 AES Milestones                                  | Planned Completion | Actual Completion | Comments   |
|--|--------------------|-------------------|--|
| Complete integrated testing in FlatSat configuration | 1/31/18            | 1/22/2018         | <ul style="list-style-type: none"> <li>• Completed test of SOXE Assy, compressor w/ recirculation, SOXE drive electronics.</li> <li>• FlatSat supporting V&amp;V with EM electronics and FSW.</li> </ul> |
| Complete SOXE Assy Qual Unit                         | 3/31/18            | 4/30/18           |  |
| Integrate and test EM                                | 5/30/18            | 10/20/18          | <ul style="list-style-type: none"> <li>• Functional tests completed, 9/27/2018</li> <li>• Will complete environmental tests in October</li> </ul>  |
| Deliver Testbed Unit to M2020                        | 6/30/18            | 12/15/18          | <ul style="list-style-type: none"> <li>• Plan to deliver December, 2018</li> </ul>   |
| Deliver FM MOXIE                                     | 10/30/18           | 2/8/19            |  |



# MOXIE

## Challenges, Issues, & Risks



### Challenges

- First of a kind development
- Operation in Mars atmosphere at high temperature (800°C) and mechanical load has revealed unusual materials-related anomalies. Each issue is unique and takes time to analyze/accept, rework or rebuild.

### Budget Issues

- Additional I&T anomalies pushed delivery into CY'19 and requires additional funds.
- Planned FY'19-'20 Science Team funding is inadequate for post-delivery effort

### Risks

| # | Risk  | Mitigation  |
|---|---|---|
| 1 | Correction and retesting of additional anomalies in I&T would consume schedule margin and financial reserves. | <ul style="list-style-type: none"><li>• Subsystems and EM have now been thoroughly tested</li></ul> |

# MOXIE

## Plans & Partnerships



- **Project (JPL) plans for FY19**
  - Complete FM MOXIE Integration, Test and deliver to M2020
  - Hand off to MOXIE Science Team
- **Science Team (MIT) major plans for remainder of FY'18 & FY'19**
  - Configure laboratory and begin execution of Calibration & Characterization Plan
  - Validate and improve Table Generation software with modeling & simulation capability
  - Support M2020 Operations Planning activities
- **Partnerships**
  - MOXIE is a partnership between HEOMD & STMD – to be operated on a SMD mission